

# Using the PEN&PAD Information Model to Support Hospital-Based Clinical Care

Heather A. Heathfield<sup>1</sup>, Nicholas R. Hardiker<sup>2</sup> and John Kirby<sup>2</sup>

<sup>1</sup>Computing Department, Manchester Metropolitan University, Manchester, UK

<sup>2</sup>Medical Informatics Group, University of Manchester, Manchester, UK

## ABSTRACT

*The PEN&PAD model for clinical record systems has been successfully used for medical records in both General Practice and hospital-based care. This paper describes experiences of using the model for developing computer-based nursing records. Results from this work show that there are some problems with directly applying the model to the nursing domain. Whilst the main purpose of the nursing record is to document and communicate a patient's care, it has several other, possibly incompatible, roles. Furthermore, the structure and content of the information contained within the nursing record is heavily influenced by the need for the nursing profession to visibly demonstrate the philosophical frameworks underlying their work. By providing new insights into the professional background of nursing records, this work has highlighted the need for nurses to clarify and make explicit, their uses of information, and also provided them with some tools to assist in this task.*

## INTRODUCTION

In 1988 the Medical Informatics Group at the University of Manchester began looking at the specific problem of computerising General Practice records, with the aim of producing systems that were both useful and usable by doctors [1]. A prototype clinical workstation for General Practitioners was developed and underwent extensive field trials. Users were highly enthusiastic about the prototype system, which proved to be sufficiently flexible and expressive to capture detailed clinical information in an intuitive and efficient manner. This work resulted in the identification of several requirements of an electronic medical record [2] and progressed to the definition of an information model capable of meeting these requirements [3]. The group also developed several tools and techniques to support the project including a User Centred Design Methodology, a novel technique of data entry called Predictive Data Entry [4] and the GRAIL formalism.

GRAIL (Galen Representation and Inference Language) is a semantic network language with subsumption and multiple inheritance which can be used to express both the terminological model necessary to guide data entry and also the semantics of clinical observations. GRAIL was developed specifically to support the clinical requirements of computer-based clinical records and is currently being used in the specification of a medical terminology base as part of the GALEN Project (Generalised Architecture for Languages, Encyclopaedias and Nomenclatures), under the auspices of Advanced Informatics in Medicine Initiative [5].

The second and current phase of the PEN&PAD project began in 1992 and is sited in an elderly care ward of a small NHS hospital in the UK. One aspect of the work has addressed issues of collaborative care, while another aims to evaluate the approach developed in phase one for use in hospital-based care. The initial presupposition was that these tools and techniques would be easily transferable from the domain of General Practitioners to clinical care in hospitals. While this assumption proved to be true for doctors' clinical records, our attempts to apply the approach to nursing records have been less successful and have uncovered several philosophical, professional and cultural barriers to the introduction of information systems to nursing practice.

This paper discusses our attempts to use the PEN&PAD approach in the nursing domain. We begin by discussing the general requirements for nursing record systems and briefly describe a prototype system for the display and manipulation of nursing data. More importantly, we look at requirements for data entry in nursing care planning. We describe the technique of Predictive Data Entry developed in phase one of the project and show how it is used in a prototype care planning system. The results of our evaluations using Predictive Data Entry in nursing are described. Finally we discuss the wider implications of using the PEN&PAD information model in light of the of our evaluation results.

## HOSPITAL-BASED NURSING CARE

The prime requirements of computer-based clinical record systems are the need for flexible and intuitive data viewing and manipulation facilities and use of recognisable clinical concepts such as a patient record, problem, daily record entry or laboratory result. Storing patient data as natural language or in a "semi-structured" manner (i.e. as composite strings) does not provide sufficient semantics to support these requirements.

Using GRAIL to represent the underlying patient data, we have developed a nursing system which enables users to view and manipulate data in a flexible and intuitive manner. The system is based on a folder (similar to an A4 ring binder) metaphor in which there are several pages or sections, including a summary page, basic patient information page, medication page, results page, progress and evaluation notes page and care plan page. This prototype has been evaluated in several user workshops and was enthusiastically received [6].

### Data Entry in Care Planning

The major role of the Nursing Care Plan is to provide a unique protocol of care which can be consulted by the patient. This accounts for the highly discursive and personalised manner in which the record is written. This style of writing is seen by the nurses as central to their professional identity and differentiates their perspective on patient care from that of the other practitioner groups. Furthermore, nurses do not deal exclusively with clinical terms, and often base their observations on the immediate environment of the patient. For example, a nurse may record that the patient "cannot walk further than the end of their garden" or that "their neighbour Anne pops in to do the cleaning every Friday".

Most existing computer-based care planning systems provide the nurse with a list of single terms or pre-defined composite phrases as the only available options for describing observations of the patient. These are seen as unacceptable by nurses as they are inflexible and not sufficiently expressive to capture data for individual patients.

The PEN&PAD philosophy is that users should be provided with data entry forms that contain all basic terms and phases that are sensible to apply in a given situation. The user is then free to combine these terms, in as much or as little detail as they wish, to form accurate and precise statements about the patient. The key idea is compositionality of observations using atomic concepts or qualifiers. This form of data entry is named "Predictive Data

Entry" in that it predicts all sensible terms and phrases that can be applied in a given situation [4] and has been used in several other studies (eg. [7] and [8]). Given the vast possible numbers of situations or contexts in which patient observations may be made, it is not possible to enumerate the contents of every data entry form. Instead, the GRAIL model of terminology is used to predict the contents of a data entry form.

### Methods

The contents of the actual data entry forms are dynamically generated from a GRAIL model of nursing terms. In order to determine which terms should appear on a given data entry form, we carried out several discussions with one or more nurses, until we had an agreed set of terms for each nursing topic and context in the study (topics mobility and elimination in the contexts of prior needs, goals, and actions).

We then produced a GRAIL model which represented the semantics of these terms, using inheritance links and user-defined links. A semantic link might be "with-support-at" which can relate the term "sitting balance" to the term "head", (which in natural language translates to "sitting balance with head support"). An inheritance link might be "bed sitting balance is-a-kind-of sitting balance", thus if we have a link that asserts "sitting balance with-support-at the back" is a sensible statement, then through the notion of inheritance, we can also say that "bed sitting balance with-support-at the back" is sensible.

GRAIL models are produced as text files, using specific keywords to indicate the relationships between terms, and then compiled into a GRAIL network, each concept being classified and positioned in the network as appropriate. The GRAIL software is written in Smalltalk-80 and runs on Hewlett Packard Workstations (apollo series 700).

Figure 1 shows a Predictive Data entry form for nurses to record problems/needs concerning mobility in stroke patients (based on the Activities of Living Model). It is generated from a GRAIL network which contains terms relevant to the nursing assessment of stroke patients.

Care planning data (as shown on the data entry form in figure 1) is entered in the context of a care plan page. The care plan page consists of several panes, each of which corresponds to a different stage in the care planning process (eg. Prior Ability, Problems and Needs, Goals and Actions).

Walking										Comment
COMPETENCE	yes	no								
AID	none	zimmer	w-zimmer	tripod	stick	crutches	gripper bar			
ASSISTANCE	0	1	2							
Stairs										
COMPETENCE	yes	no								
ADAPTATION	none	double rail	chair lift	lift						
ASSISTANCE	0	1	2							
Transfers										
COMPETENCE	yes	no								
NURSING AID	none	sling	hoist							
AID	none	zimmer	w-zimmer	tripod	stick	crutches	gripper bar			
ASSISTANCE	0	1	2							
Wheelchair										
ASSISTANCE	yes	no								
WHEELCHAIR TYPE	manual	electric								
Standing										
COMPETENCE	yes	no								
AID	none	zimmer	w-zimmer	tripod	stick	crutches	gripper bar			
ASSISTANCE	0	1	2							
Sitting Balance										
ABILITY	yes	no								
<input type="button" value="(Accept)"/> <input type="button" value="(Abandon)"/>										

Figure 1. A Predictive Data Entry form for recording mobility problems/needs for stroke patients

Individual sections of the care plan are filled-in as required using Predictive Data Entry forms. As each Predictive Data Entry form is completed and accepted by the nurse, the information recorded is displayed in the relevant pane on the care plan page.

The Predictive Data Entry technique for entering care plan data was evaluated by nurses in user workshop:

- **User Training.** The first part of training involves the evaluator giving a demonstration of the system to the user, complemented by commentary and explanations. The user then carries out several training tasks and assistance is provided as necessary.
- **Evaluation Scenarios.** The user is asked to carry out a set of tasks, reading them from a paper script, without the aid of the evaluator if possible. These tasks are based around real situations that may arise on the ward.
- **Observations.** We observed the users carrying out the evaluation scenarios and made notes of any problems encountered or items of interest that occurred.

- **Questionnaires and discussion.** The users were asked to complete two sections of a questionnaire. The first section (completed before training) asked about general computer experience and attitudes to computerised patient records. The second section, (completed after the evaluation scenarios) asked about specific aspects of the system. After the evaluation exercises had been completed, users were engaged in a general discussion which gave them a chance to offer their opinions in a less structured manner.

## EVALUATION RESULTS

A total of 10 Registered Nurses, including 2 ward managers, performed evaluations on the system. The evaluation questionnaires were put as questions with multiple choice pre-set answers (with space for comments), and also open-ended questions. An example of the former might be "How easy to understand are the care plans?" with possible replies "very/quite/average/ not easy/difficult", whilst an example of the latter might be "What is your

impression of the care plans?". The results were collated by counting the number of replies in each category for the multiple choice questions, and classifying comments into obvious themes for the open-ended questions. Some of the replies are presented below.

In response to the question "Do the forms contain the right level of detail?", three nurses replied "too little" and seven "about right". When asked "Are there other things that ought to be added to the form?" the responses were "none" or cited administration data such as review dates, rather than additional descriptive terms concerning the patient. In response to the question "How well do the forms enable you to say what you would want to say about a patient?", four nurses replied "well", four replied "average", and two replied "poor". When asked "What is your overall impression of the forms?" two nurses replied "very good" and eight replied "good". On a general level, four users thought that it was "very" easy to use the computer to create a care plan, two thought it "quite" easy, and three thought it "average". When asked to compare the computer-based approach to the current paper-based one, the majority of users replied that it was easier and the same speed or faster using the computer system. Responses to the question "Can you imagine using this approach to care planning on a regular day to day basis?" were reserved, with five nurses replying "possibly" and four "definitely".

In the discussions held after the evaluation and questionnaires had been completed, nurses were more forthcoming about their reservations and critical of the plans produced. Many nurses were particularly concerned about their plans becoming standardised and not reflecting the individual nature of care.

We also performed limited experiments transforming the data displayed in the care plans into a more English-like form, yet the output was still seen as unacceptable to the majority of nurses. However, when asked to point out specific areas where the care plan was inadequate the nurses found it difficult to articulate their concerns.

## DISCUSSION

These results appear to be contradictory and somewhat inconclusive given that although Predictive Data Entry forms were generally perceived by nurses as sufficiently expressive and flexible to capture most of the information necessary to formulate care plans, the resulting care plans

themselves were perceived as lacking sufficient information to carry out patient care. These are preliminary results based upon only ten evaluations. Furthermore, none of the nurses involved had any previous experience of computer-based care planning systems. Whilst this latter fact is necessary to ensure that the requirements work we carry out with users is not influenced by their prior experience with other systems, it does not enable us to compare our system with others which is also important. However, our future plans do include such comparative evaluations with users from another site who do have experience with other systems.

Our work has raised a number of complex issues concerning the computerisation of nursing records:

- The contradictory nature of our results led us to the observation that nursing care plans fulfill several, possibly incompatible, roles. While the primary purpose of a care plan is to document and communicate a patient's care, several other roles were identified. These included: a legal document; a notebook; a things-to-do list; a record of alibi in the event of misadventure; a prompter for the hand-over of care from one nurse to another or simply a record of the presence of a nurse [9].

- As argued in [10], nurses have traditionally found it very difficult to define and describe patient care without devaluing the skill required. A variety of frameworks have been introduced to assist in this task, including the nursing process and models for nursing practice (e.g. [11]). These frameworks however have little regard for the structure or content of the information needed for patient care.

- The purpose of the nursing record is still not fully understood and much of the valuable information contained within nursing records is "swamped by mandatory obligations or culturally driven information" [9]. Therefore, attempts to develop and evaluate nursing information systems are problematic.

The recording practices of doctors and other clinical staff differ significantly as illustrated by our work in the nursing domain, and it is not obvious whether the PEN&PAD model is directly transferable from medicine to nursing care, given the strong philosophical, professional and cultural barriers that exist. While we believe that the model can capture the actual information content of the nursing record, this are other issues that must be addressed. The nursing profession must first clarify the disparity between what the nursing record is supposed to do and what it represents before we can consider introducing information systems. However, our

work has been useful in that it does highlight the need to do this and provides some tools to assist in the task.

The situation is further complicated by the introduction of various abstracting mechanisms in nursing. For example, controlled vocabularies, such as Nursing Diagnoses, define a subset of terms and phrases that can be used to describe patient care and so restrict the information model (which should consist of all of those things that can be sensibly said about what nurses have heard, seen, thought or done). Minimum data sets, which have been devised to serve specific purposes and often conflict with the recording needs of daily nursing care, are process models of what ought to be done. Basing computer record systems on such abstractions renders the information they record distorted and useless for all except a single pre-defined purpose. As we have argued in [2] clinical information, as it is generated and used during patient care, is the only sound basis for a model of the clinical record. Our work in care planning has not made this argument any less valid and is valuable in that it has made explicit the multiple and often conflicting roles of nursing care plans. We can use this insight to contribute to the current debate over the structure and content of care plans [9], and can assist nurses in finding solutions.

This work has illustrated that the development of clinical information systems is not reliant simply on the strength of the technical solutions employed. Rather there are other, potentially more powerful, factors which affect the usefulness and acceptance of an information system. In particular there are social and cultural issues that need to be addressed before we can consider computer-based clinical records.

One method of influencing these factors is through education, moving from the current situation where learning by example is the norm, to more theoretically based learning. Another method is to conduct evaluations of the system on the ward, rather than an isolated laboratory evaluation, with the hope that routine use of the system will reveal to nurses that much of the information written in care plans is not necessary to daily care. We are currently setting up field trials on the ward with our system with the hope of exploring these issues further. These observations reflect the general awareness of the medical informatics community, that is beginning to widen its considerations away from purely technical matters, to address human, cultural and organisational issues [12].

## References

- [1] Howkins TJ, Kay S, Rector AL, Goble CA, Horan B, Nowlan A, Wilson A. An overview of the PEN&PAD project. MIE 90; Lecture Notes in Medical Informatics NO. 40. Berlin. Springer-Verlag 1990: 73-8.
- [2] Rector AL, Nowlan WA, Kay S. Foundations of an electronic medical record. *Methods Inf Med* (1991) 30: 179-86.
- [3] Rector AL, Nowlan WA, Kay S, Goble CA, Howkins TJ. A framework for modelling the electronic medical record. *Methods Inf Med* (1993) 32: 109-119.
- [4] Nowlan A and Rector A. Medical knowledge representation and predictive data entry. In: *Lecture Notes in Medical Informatics 1991*; 44 (Springer Verlag, M Stefanelli, A Hasman, M Fieschi, J Talmon (Eds) 1991).
- [5] GALEN, General Architecture for Language, Encyclopaedias and Nomenclatures in Medicine. Project 2012, AIM Initiative, EC. Technical Annex.
- [6] Heathfield HA, Hardiker N, Kirby J, Tallis R, Gonsalkarale M. The PEN&PAD Medical Record Model: A Report of its Use in the Development of a Clinical Record System for Hospital-based Care of the Elderly. Submitted to: *Methods Inf Med* April 1994.
- [7] Kuhn K, Zemmler M, Reichert C, Heinlein D, Rosser D. Structured data collection and knowledge-based user guidance for abdominal ultrasound reporting. In: Safron C (ed) *Proc 17th SCAMC*, McGraw-Hill, New York, 1993, 311-315.
- [8] Benoit RG, Canfield K, Teilelbaum S, Cushing B, Stamp N, Durham A, Ondrish A, Woodman M, Bame W. Frame-based clinical data entry: design issues for physician acceptance. In: Lun KC, Degoulet P, Piemme TE, Rienhoff O (eds) *MEDINFO 92*, North-Holland, Amsterdam, 1992, 1280-1285.
- [9] Hardiker NR. Towards an information infrastructure for nursing: a critique of the nursing record. *Information Technology in Nursing* (1994) 6.1: 7-9.
- [10] Dukes S, Copp G. Hidden nursing. *Nursing Times* 1992; 88, 17: 40-2.
- [11] Pearson A, Vaughan B. *Nursing models for practice*. Butterworth-Heinemann Ltd 1991.
- [12] Heathfield HA, Wyatt J. Philosophies for the design and development of clinical decision-support systems. *Methods Inf Med* 1993; 32: 1-8.